

ALGAL DEBRIS-FACIES IN THE CRETACEOUS OF THE MIDDLE EAST

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Abstract. A rock-type common in the Lower and Middle Cretaceous of the Middle East consists of fine algal debris in a calcareous marly matrix. The algae, of which *Permocalculus* and *Munieria* are the commonest, are described and illustrated both as fragments and as complete segments; the origin of the deposits is discussed by analogy with present-day algal sediments.

INTRODUCTION

A CHARACTERISTIC rock-facies in the Cretaceous of the Middle East is that of fine-grained limy marls and marly limestones containing numerous fragments of calcareous algae: in thin section these rocks show the algal fragments as white against a grey background. This 'debris-facies' is known from Iraq, Oman, and the Hadhramaut: the component algal genera are known variously from Europe and North Africa, and the facies probably has a wide Tethyan distribution. In the Middle East it occurs locally at various Lower and Middle Cretaceous levels, but is particularly characteristic of the Barremian-Aptian horizon.

The algae are sometimes accompanied by foraminifera, and occasionally by other organisms, and there is a varying proportion of non-algal debris, but it is the algal fragments which are the distinctive features of the rock: so much so, that particular types of fragments were used for stratigraphic purposes before they were definitely recognized and referred to genera and species. Much of this debris is too small for the particles to be individually recognizable: identification has therefore depended upon rare fortunate preservation of larger pieces, patient comparison of all fragments with theoretically-possible sections of suspected identification-species, and such illustrations of fragments in thin-section as exist in the general literature.

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THE FLORA

The genera represented are few in number; they are most commonly *Permocalculus* and *Munieria*, secondarily *Actinoporella*, *Clypeina*, and *Salpingoporella*, and more rarely *Triploporella* and one or two dasyclads and codiacids not yet determined. Acicularian spicules are not uncommon: these are naturally dissociated after the death of the plant, and behave similarly during sedimentation to the mechanically broken fragments of the other genera.

Permocalculus (Pl. 45, 47, 48) is represented by at least two species: the common *P. inopinatus* (Elliott 1956) in the Barremian-Aptian, and a new species from the Albian-Cenomanian, described below. Other species are not yet fully known. The genus, which ranges from the Permian, has many points in common with the modern *Galaxaura* (Pl. 46, figs. 1, 2), a segmented chaetangioid alga which is an inhabitant of warm shallow

littoral waters in the Pacific, West Indies, and elsewhere: the relationship has been discussed elsewhere in detail (Elliott 1955a, 1956), but it seems likely that this kind of plant has always grown in much the same environment. Cretaceous *Permocalculus* are known also from France and North Africa. In the Middle East innumerable fragments of segments are common, and are recognizable by the denticulated edge occasioned by pores in the calcified crust: single complete segments, and two or more attached segments, are very rare.

Munieria baconica Deecke was described from the Hungarian Lower Cretaceous (Deecke 1883), and subsequently recorded by Taeger (1936) from the Aptian of this area. A reconstruction attempted by Pia (1920) shows the alga to have a thin main stem with well-spaced horizontal whorls or verticils of about twelve or fourteen relatively coarse straight primary branches. Both stem and verticils are coated with calcareous matter, the latter very thickly, so that around the stem they are fused into coarse ring-like structures. Carozzi (1948) recorded this species from the Swiss Purbeckian, giving a valuable set of figures of thin-sections of debris. His material seems to be of a larger form having a proportionally wider central stem-canal than that of the type, and about sixteen primary branches per whorl. The Middle East material comes from the same approximate horizon as the type-material, as dated by foraminifera and other fossils, but it shows the characters of the older, Swiss, material, and is identified by reference to Carozzi's text-figures.

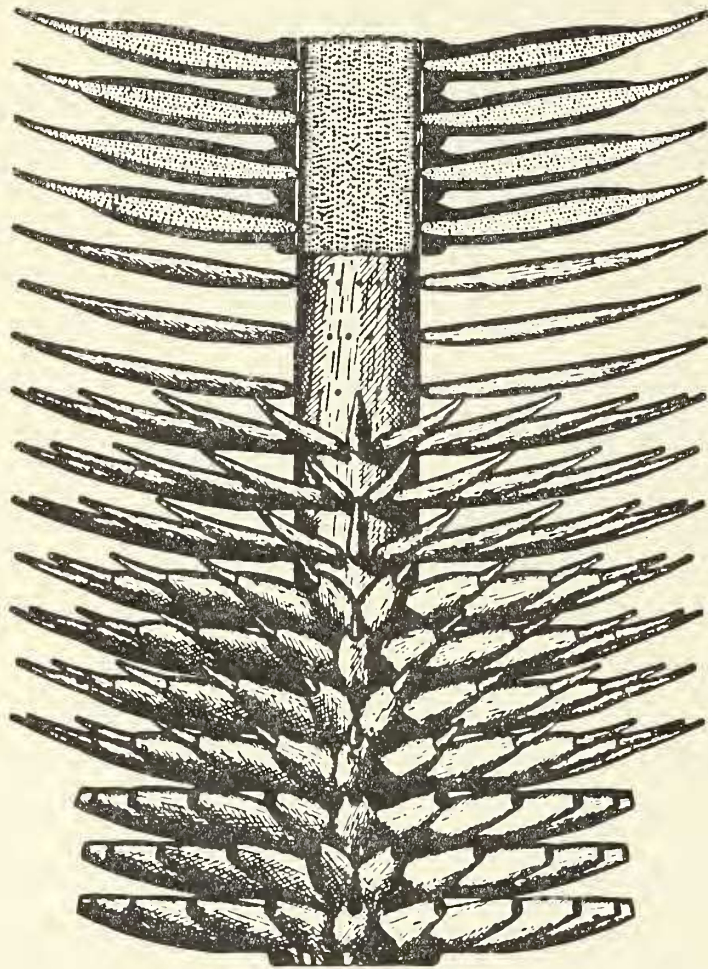
Munieria is the most fragmentary alga of all in the debris-facies (Pl. 45, fig. 4), and most of the finer fragments, associated with recognizable *Munieria*-crumbs are intrinsically quite indeterminable. The coarser fragments show in thin-section as little hooked and looped scraps. Such as have been recognized have been correlated with Carozzi's Swiss specimens determined by him as *M. baconia*, and this applies also to the very rare sections of complete whorls (Pl. 48, fig. 1). It is especially characteristic of the Barremian-Aptian, though met with rarely in the older Cretaceous, and it extends up also into the Albian.

Actinoporella was described from the Polish Portlandian (Alth 1878, 1882), and *A. podolica* (Alth) has been recorded from the Swiss Purbeckian (Carozzi 1948) and the north Iraq Valanginian-Hauterivian (Elliott 1955b, and Pl. 47, fig. 5 of this paper). Somewhat similar in general plan to *Munieria* (see Pia's restoration reproduced here in text-fig. 1) but differing in proportions and number of primary branches to a whorl, the calcareous skeleton is more delicate. Curiously, in spite of this, it seems to have been less fragile, and the fossil remains in the debris-facies are less fragmentary (Pl. 45, fig. 1), often showing in section as chains of connected rings. Possibly the calcareous coating was less porous than in *Munieria*.

Of the minor elements in the debris-flora, *Clypeina*, long known from Jurassic and Tertiary, has now been recorded from many levels in the Cretaceous (Emberger 1957); it is uncommon so far as known in the Middle East Cretaceous. *Salpingoporella* is represented by occasional remains (Pl. 46, fig. 3) comparable with the type *S. mühlbergi* (Lorenz), known from the Barremian-Aptian of Switzerland and France. Dissociated acicularian spicules (Pl. 45, fig. 2), some identified as *Acicularia* cf. *antiqua* Pia, a Cretaceous species, are not uncommon. Such spicules are the skeletal remains of the terminal disks of *Acicularia*, a genus still surviving and somewhat like the more familiar Recent *Acetabularia* or 'Mermaids' wineglass', a shallow warm-water genus.

CONDITIONS OF ACCUMULATION

Living algae comparable to those listed above are all littoral or lagoonal inhabitants of warm, very shallow waters, and it is reasonable to suppose that the Cretaceous flora grew under similar conditions. The rocks in which their fragmentary remains occur,



TEXT-FIG. 1. *Actinoporella podolica* (Alth), from the Upper Jurassic of Poland, as reconstructed by Pia (1920): $\times 20$ approx.

EXPLANATION OF PLATE 45

- Thin-sections in the collections of the Geological Department, Iraq Petroleum Co., Ltd., London.
1. Debris-facies, showing *Actinoporella podolica* (Alth), $\times 28$. Valanginian-Hauterivian of Banik, Mosul Liwa, northern Iraq; reg. no. Wl. 11539.
 2. Debris-facies, showing *Acicularia* sp., $\times 55$. Barremian of Sarmord, Sulemania Liwa, north-eastern Iraq; reg. no. Wl. 10381.
 3. Debris-facies; *Permocalculus inopinatus* Elliott and *Orbitolina* sp., $\times 15$. Aptian of Koi Sanjak, Erbil Liwa, north-eastern Iraq; reg. no. DM. 539.
 4. Debris-facies; fine debris including '*Munieria baconica* Deecke', $\times 15$. Aptian-Albian of Surdash, Sulemania Liwa, north-eastern Iraq; reg. no. Wl. 10396.

EXPLANATION OF PLATE 46

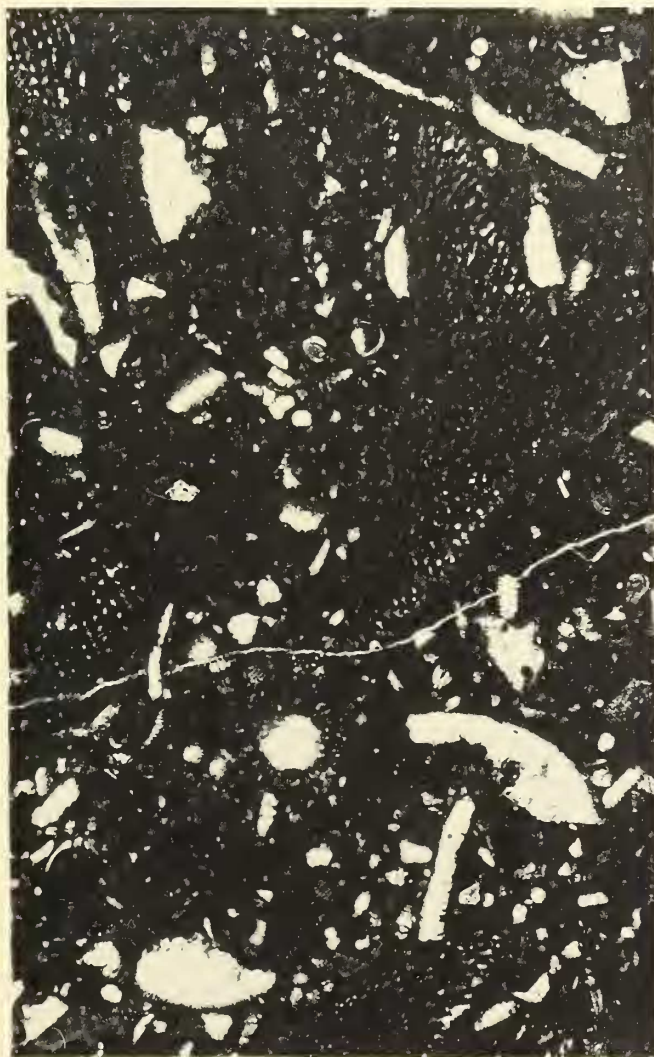
1. *Galaxaura cylindrica* (Sol.) Kjellm. Portion of growth $\times 2$, to show calcified segments as they occur during life. Recent; Boston Beach, Portland Parish, Jamaica, B.W.I.
2. *Galaxaura* sp. Flattened segments $\times 5$, to illustrate paired growth of segments in this type of alga. Recent; West Indies.
3. Debris-facies, showing *Salpingoporella* cf. *annulata* (Lorenz), $\times 30$. Valanginian-Hauterivian of Jebel Gara, Mosul Liwa, northern Iraq; reg. no. Wl. 6380, in the Geological Department, Iraq Petroleum Co., Ltd., London.



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